A total of 10,200 hatched larvae were transferred to 20-50 liter glass aquaria for rearing (a small percentage of larval mortalities occurred directly after hatching). The aquaria were maintained in a temperature-controlled water bath, with 80% of the water changed daily. Water salinity was maintained at 5 ppt (Instant Ocean salt). Larvae were fed rotifers (*Brachionus plicatilis*) raised in monoculture on cultured algae (*Nannochloropsis oculata*) and enriched in Selco media. Rotifers were introduced into the aquaria at a final concentration of 5-12 per milliliter. In addition, live concentrates of cultured algae were added to aquaria water in the morning and late afternoon to stimulate feeding. After 30 days of rearing, larvae were counted, sampled for length measurements, and transferred to the SWP site for further rearing. The survival rate from hatching to 30 days was 7-67% in the various aquaria, with a mean survival rate of 49%. Total length of the larvae varied between 7.5 and 13.5 mm, with larger larvae developing in the 50-liter aquaria and smaller larvae in the 20-liter aquaria.

Post-larval smelt (age about 30 days and length about 11 mm) are now being reared at the SWP site. Rearing this life stage is new to the SWP site, and procedures are being developed as the season progresses. Upon arrival at the SWP site, larvae are transferred to 120-liter flow-through circular tanks seeded with natural zooplankton and artemia nauplii. Zooplankton 240-400 microns in size are collected by sieving delta water. These prey consist primarily of juvenile stages of copepods and are fed to the larvae each morning. At periodic intervals, larval samples are preserved for later measurements and stomach content analysis; samples of the zooplankton population are also preserved. As the larvae develop, procedures at the SWP are modified to enhance growth and survival. For example, we find that a small spotlight (25 watt) directed on the surface of the water creates a dense zone of feeding activity. The post-larval smelt are visual hunters, and the light may help them locate prey. Larvae feed by assuming an "S-posture" and thrusting forward to capture prey. We are finding that weaning the post-larvae from artemia to zooplankton requires exclusive feeding on natural zooplankton 1-2 hours before adding cultured artemia. These and other changes in larval rearing procedures are in place for the new group of post-larvae recently received from UC-Davis and for the last group of fish due to arrive in mid-July.

In summary, the culture of delta smelt, as with many "new" species, is initially difficult but has proven to be technically feasible. The life cycle of delta smelt is characterized by adults living in brackish water and spawning in fresh water, and a by a prolonged larval stage returning to brackish water and feeding on microzooplankton. The high sensitivity of mature adults to stress and the prolonged larval stage requiring live food are two difficult challenges in delta smelt culture; these two stages are also likely to be the most sensitive life stages in the wild population.

Literature Cited

Lindberg, J. C. February, 1996. Delta Smelt Culture, State Water Site, 1995. California Department of Water Resources Report, Sacramento.

Slide Show on Bay/Delta Geologic Evolution

Ken Lajoie will be presenting his slide show on the geologic evolution of the bay/delta estuary — 1 p.m. August 9, 1997, at the Corps of Engineers' Bay Model in Sausalito.

Anyone who missed Ken's presentation at the annual Asilomar workshop should take advantage of this opportunity to see a great slide show.

Ken has graciously consented to describe his findings in the January issue of the *Newsletter*.

Noteworthy for Managers

Randall Brown

This is the first in a series of quarterly columns that will describe some significant management activities in the Interagency Ecological Program, around the estuary, and in the watershed that directly or indirectly will shape the Program's future.

Spring Chinook Candidacy

On June 13, 1997, the California Fish and Game Commission advanced the Central Valley spring run of chinook salmon to candidacy. During the next 12 months, DFG staff will prepare a status report to be used by the Commission to determine if spring chinook should be listed pursuant to the California Endangered Species Act and, if listed, whether threatened or endangered.

During candidacy, spring chinook receive the same protection as a listed species. The Commission issued a special order allowing the incidental take of spring chinook under specified conditions. In the bay/delta, the Commission basically stipulated that incidental take of spring chinook juveniles at the CVP and SWP intakes is allowed provided the projects operate as agreed to in the 1994 Bay/Delta Accord and described in the 1995 SWRCB Water Quality Control Plan. The Commission did require a workshop in late August to provide them with more information on how flexibility in the Accord and Water Quality Control Plan will be used to help protect spring chinook.

Information about spring run migration and abundance will be essential in developing operational and other measures to protect and restore spring run. The Interagency Program's Central Valley Salmon project work team and its spring run and delta work groups will be developing the monitoring and special studies needed to provide this information. Last fall's Category III program approved $450,000 for the UC-Davis Bodega Marine Laboratory to determine if genetic techniques can be used to distinguish spring chinook from the other three Central Valley chinook races, and perhaps among individual stocks. The project, funded by Metropolitan Water District, will begin August 1, 1997. As part of its Feather River fish studies, DWR is funding a program to determine if the microchemistry of the salmon's otoliths (ear bones) will enable biologists to determine the stream origin of fish captured in the lower rivers, estuary, and the ocean. This study, by UC-Berkeley and Lawrence Livermore Laboratory researchers will begin around the middle of August. The spring run and delta groups are refining their proposed monitoring programs for this fall and spring.

NMFS Considerations

NMFS is expected to announce its decision on listing Central Valley steelhead by August 6, 1997. The announcement on the other Central Valley chinook races is expected in early 1998.

On a separate issue, NMFS will soon release a public review draft of the Winter Run Recovery Plan. Winter run escapements have been looking better in recent years, and the 1997 escapement is no exception. Initial run estimates are in the range of 450 to 780, which is coming off an estimated escapement of 189 in 1994, the lowest on record. The final estimate for 1997 will be available after August 1.

Central Valley Project Improvement Act

Several aspects of the federal act will affect the Interagency Program. Two key aspects are:

- Anadromous Fish Restoration Plan and Management of (b)(2) Water. On June 24, the Department of Interior released the draft AFRP and draft administrative proposals on the plan and use of the b2 water (the 800,000 acre-feet dedicated to fish and wildlife). After the release, Interior established three teams (fish, toolbox, and modeling) to develop a 5-year plan for implementing the AFRP, including management of the 800,000 acre-feet of CVP water. The 5-year plan is due this fall.

In the delta, the stakeholder-driven process will apparently use an adaptive management approach, much along the lines of the Vernalis (or San Joaquin) Adaptive Management Program. Under this approach, instead of simply proposing and enacting a protective or recovery measure and hoping for the best, the measures will involve testable hypotheses, data collection (monitoring and special studies), data analysis, and modifying (as necessary) the measure being tested. Interagency Program staff will be involved in all phases of the adaptive management.

- Comprehensive Assessment and Monitoring Program (CAMP).

In March 1997, FWS released the final implementation program report for CAMP. The CAMP is designed to help Interior assess the overall effectiveness of actions to restore anadromous fish and to determine the relative effectiveness of specific categories of measures. CAMP will fund monitoring and special studies, and Interagency Program staff and

management will work with Interior staff to ensure that the two efforts are coordinated. This year CAMP is providing about $90,000 to the Interagency Program to put their data into the IEP relational database.

CALFED Bay/Delta Program

CALFED's Ecosystem Restoration Program Plan contains three elements of particular interest to the Interagency Program — monitoring, indicators, and focused research. Over the next few months, these elements, including implementation, will be fleshed out. Interagency Program staff and management are critical in the development and review process as well as in implementation. In a recent meeting, Lester Snow, CALFED Program Executive Director, challenged the Interagency Coordinators to determine how the program should fit into the comprehensive monitoring and focused research efforts expected to come out of the CALFED process.

In late June, the CALFED Bay/Delta Program released its 1997 request for proposals called for under Category III of the 1994 Bay/Delta Accord. Up to $70 million will be available for approved Category III projects, although all of it may not be allocated in this round. CALFED staff received over 2,000 requests for the RFP. Some of the funding may go to support projects submitted by Interagency Program agencies, and some will be allocated to studies by consultants and university scientists who provide information essential to our understanding of estuarine and riverine processes. The challenge will be to integrate the new information into a collective ecosystem database and make it available to managers. The Interagency Program is a logical entity to take on this integration.

The CALFED Operations Group has been a major recipient of Interagency Program data and information. One program providing this information has been real-time monitoring, although the delta smelt, summer tow-net, fall midwater trawl, and salmon monitoring have also been important data sources. Both the Operations Group and Interagency Program staff are continually assessing information needs and revising the program to meet these needs, but budget, equipment, and personnel considerations often limit program flexibility.

UC-Davis EPA/NSF Grant

"An Integrated Approach to Assessing Water Management Options in Major Watershed" is a $1.3 million, 3-year grant from EPA and NSF to develop an integrated set of hydrologic, water quality, fish, watershed, and economic models of the Sacramento River watershed from Shasta Dam and Reservoir through the delta. The principal investigator is Paul Sabatier, who has nine co-principal investigators. Paul has organized an advisory committee, which includes Bruce Herbold and me for the Interagency Program, as well as Sam Luoma, chair of our Science Advisory Group.

The program has salmon modeling, temperature modeling, and delta particle tracking components, which are of particular interest to program staff. Coordination of this project with the Interagency Program will occur through participation in the advisory committee and on individual project work teams. We may be asking program investigators to share their information at a special session of the annual Asilomar workshop.

Proposal to NSF

A proposal, "Long-Term Ecological Research in Land/Ocean Margin Ecosystems — Trophic Consequences of Biological and Physical Fluxes in a Temperate Estuary", was forwarded to the National Science Foundation in late June. The proposal requests about $3.5 million over a 6-year period. The principal investigator is Wim Kimmerer, along with 14 co-principal investigators. The program has two components:

- Long-term research and monitoring to track variability in major ecosystem components and answer questions about potential mechanisms.
- Shorter-term studies to answer specific questions about the effects of flow or ocean conditions, mechanisms of response, and strength of trophic linkages.

Should the project be approved (they will know late this fall), the Interagency Program will be involved in several ways. Three of the co-principal investigators are program staff (Kathy Hieb, Karl Jacobs, and Jim Orsi), and I have been nominated to serve on the advisory committee. The Interagency Program database will provide data essential to carrying out the program objectives. Some of the work now conducted by the Estuarine Ecology Team will be counted as part of the state match. Finally, the Interagency Program's relational database may be the repository for much of the data coming out of these efforts.

Interagency Program Coordinators' Retreat

On July 30 (and perhaps July 31), the Coordinators will take this and other information into consideration in discussions to improve the present program and develop some future scenarios. In preparation for the meeting, the Coordinators will be meeting with about 20 key stakeholders and agency representatives to obtain their views on program direction. Results of the meeting will be made available in the October issue of the *Newsletter* and will be discussed at all program levels. Recommendations for significant program changes will be discussed at a meeting of the Management Level Advisory Group before being taken to the Agency Directors for consideration. The goal is to develop a long-term (5-year) plan to best meet the information needs of resource managers and regulatory agencies.

Spring Runoff Pulse from the Sierra Nevada

D.R. Cayan, D.H. Peterson, L. Riddle, M.D. Dettinger, and R. Smith

Abstract

A spring runoff pulse that makes the transition from low streamflow conditions in winter to the high streamflow conditions in the later spring and early summer is identified in the Merced River record from the Sierra Nevada. The timing of the pulse is delayed with greater seasonal accumulation of snowpack in the Yosemite region. Also, the runoff pulse is triggered by a regional weather fluctuation that establishes a warm high-pressure ridge over the California region during the spring (mid-March to Mid-May). This ridge often blankets the entire western United States, and it is found that a simultaneous pulse occurs over a broad collection of high-elevation streams in the region.

Introduction

Snowmelt runoff from the Sierra Nevada constitutes a large component of the California water supply and contributes greatly to the freshwater budget associated with the San Francisco Bay system. Just about every year there is one pulse of snowmelt runoff (streamflow) that marks the transition of the Sierra climate from winter to spring. Three examples during the early 1980s from Merced River hydrographs show a very late spring pulse (1983), a very early spring pulse (1985), and a fairly average time of the spring pulse (1980) in Figure 1.

The record of daily flows (1948-1996) at Happy Isles, in Yosemite National Park, provides a convenient history from which we identified the spring pulse (Figure 2). On average, the pulse at Happy Isles occurs in mid-April, but it varies considerably - as early as mid-March and as late as mid-May. Also superimposed on the spring rise in streamflow are several day-long peaks and troughs in the streamflow that are the subject of companion studies aimed at modeling (Peterson *et al*, this issue) and prediction (Dettinger *et al*, this issue).

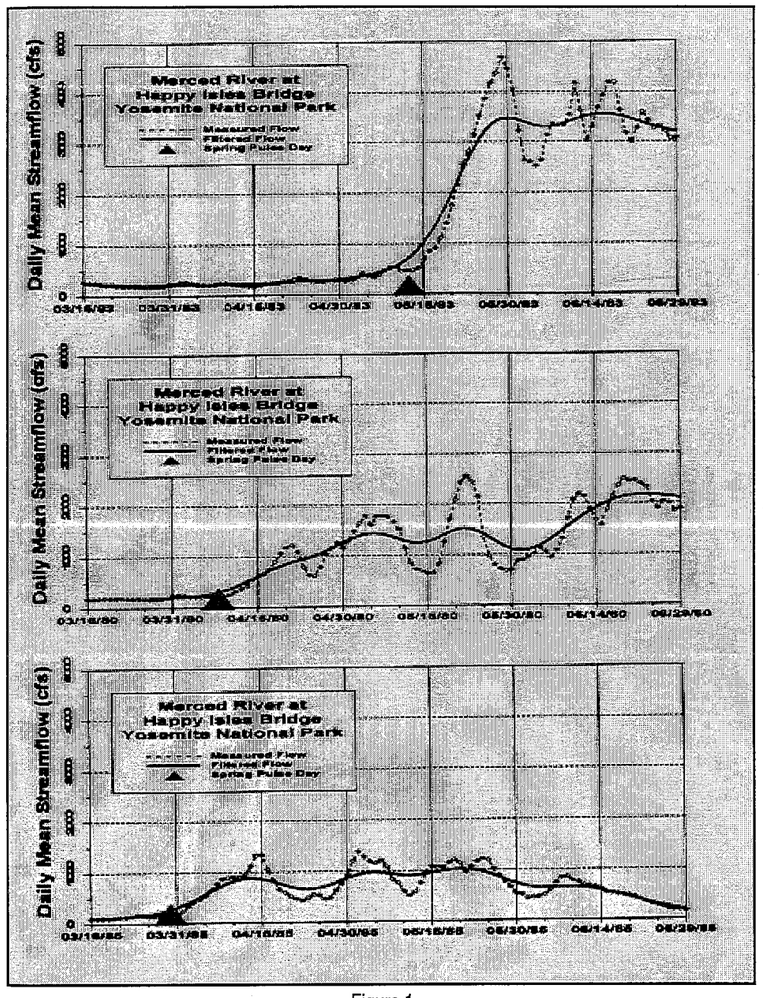

Figure 1
SPRING RUNOFF PULSE AT HAPPY ISLES GAGE, MERCED RIVER, YOSEMITE NATIONAL PARK
Initial day of pulse is marked by triangle.
Solid and dashed curves show actual daily and smoothed flows for each of selected years.